Instruction Book

FREQUENCY STANDARD

Type XSA BN 444111

EF-4/6/5/92
ROHDE & SCHWARZ SALES CO. (U.S.A.) INC.

MP MASTER
MA22471

ROHDE & SCHWARZ

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ROHDE & SCHWARZ SALES CO. (U.S.A.) INC.
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Note: Always quote the Type and Order Number (BN) in addition to the Serial Number (FNr.) of the set when asking for technical information and, in particular, when ordering repair parts.

Edition R 6818/360

(Translation of the German edition R 6816/360)

ROHDE & SCHWARZ, MÜNCHEN

1 Specifications

Output frequency	1 mc and 0.1 mc
Output voltage at 1 mc	1 v, output impedance 60 Ω, unbalanced; coaxial 15-mm socket at the front panel
Output voltage at 0.1 mc	1 v, output impedance 60 Ω, unbalanced; coaxial 15-mm socket at the front panel 1 v, output impedance 18 Ω, unbalanced; multi-point connector St 2 at the rear
Distortion	less than 3 %
Spurious modulation	down more than 60 db
Frequency variations with supply voltage fluctuations of ± 10 % and ambient temperature fluctuations of ± 10°C	
within 1 minute	less than 5 parts in 10^{10}
within 1 day	less than 1 part in 10^{9}
Mean daily frequency drift after a service time of 30 days	less than 1 part in 10^{9}
Frequency adjustment	linear, calibrated
variation span	2 parts in 10^{6}
indication	on counter, in terms of 1 part in 10^{10}
operation	manual; remote control possible by built-in synchro-system, automatic by separate frequency controller
Permissible ambient temperature	0 to + 40°C

Operating temperature of the oven	$68^{\circ}C$	
Ambient temperature change reduction factor	greater than 10,000	
Valves, etc.	3 valves E 92 CC 1 valve EAA 901 S 7 valves EF 800 1 valve EL 803 2 reference tubes 85 A 2 1 fuse 0.6 amp C DIN 41571	
Power supply	90 v, 110 v, 130 v, 200 v, 220 v, 240 v, selectable, 47 to 63 cps, approx. 68 va	
Order number	BN 444 111 in cabinet with front cover	BN 444 111 D rack-mounting unit built to German standard DIN 41490
Dimensions	570 x 234 x 378 mm (R&S Standard Cabinet 56)	520 x 202 x 337 mm rack-mounting unit
Weight	about 30 kg	about 20 kg

2 Uses

The Frequency Standard Type XSA delivers the frequencies of 1 mc and 0.1 mc at a low power, but high accuracy and stability. It has been specially designed for use in the R&S Standard Time Systems Type CAA, but finds application as a self-contained unit wherever the frequencies of 1 mc and 0.1 mc are required with high accuracy. Particularly fine frequency adjustment permits the XSA to be accurately tuned to an available frequency standard. Remote control of the frequency adjustment via a synchro-system, e.g. from the Control Panel Type XHA, is of particular advantage when the frequency standard is located in a separate room. Automatic frequency adjustment via the synchro-system is obtained by insertion of a frequency controller driven by the available frequency standard.

3 Description

The instrument consists of four components: the oscillator chassis, the regenerative frequency divider, the power supply and the heater-voltage regulator.

3.1 Oscillator Chassis

The oscillator chassis is a robust unit spring-seated on the mounting plate. It comprises the oven, the crystal oscillator, Rö1 with its variable capacitor for frequency correction, the amplifier/AGC stage Rö2-Rö7, and the 1-mc output stage Rö5.

3.1.1 Oven

The oven consists of 4 metal cylinders put inside each other and separated by heat insulating supports. The outermost heat-insulating cylinder is followed by the a-c heated outer oven which contains the thermometer cartridge housing the 66°C mercury contact thermometer Th1. Enclosed in the outer oven is the d-c heated inner oven containing the cartridge for the 68°C thermometer Th2. This cartridge projects through a hole of the outer oven so that both thermometer cartridges are accessible and replaceable through an opening in the outermost cylinder (Fig.1). The inner oven encloses an unheated copper cylinder which contains the 1-mc vacuum crystal Q1 and compensates for slight residual temperature fluctuations of the inner oven by its large thermal capacity.

3.1.2 Crystal Oscillator

The frequency of 1 mc is generated by the crystal oscillator Rö1. Long years of experience have persuaded us to choose the Pierce circuit where the vacuum-sealed crystal operates on its parallel-resonant frequency. The series and parallel capacitors C3 to C9 compensate for the frequency error within the tolerance of the crystal and give the variable capacitor C1 a capacitance range sufficient to provide for the crystal a total trimming range of

$$\frac{\Delta f}{f} = 2 \cdot 10^{-6}$$

3.1.3 Amplifier/AGC Stage; 1-mc Output Stage

To minimize the influence which the following stages have on the frequency of the crystal oscillator, the buffer valve Rö2 connects to the anode choke L1 through a low-valued resistance. The anode circuit of the buffer amplifier is tuned to 1 mc and adjustable with the aid of L2. A voltage is inductively coupled out of the resonant circuit L2-C41 (soldered points 2-4) to drive the regenerative frequency divider via a plug-in connection and an r-f cable. This voltage is also used to drive the output stage for 1 mc (Rö5, L3) after passing through a voltage divider comprised of C50, R25 and the control grid capacitance of Rö5. In addition, another voltage is coupled directly from the resonant circuit L2-C41 via C45 to the control diode Rö7. This control diode produces a negative d-c voltage of approximately -9 v.

A highly regulated positive d-c voltage of approximately +7.5 v obtained from the voltage divider R22-R23 is added to the -9 v. The sum voltage of approximately -1.5 v is used, after passing through the filter C33-R14-C18 to the control grid of the crystal oscillator stage Rö1, to hold the r-f output voltage of the crystal oscillator constant to approximately 70 mv.

3.2 Regenerative Frequency Divider

The operating principle of the regenerative frequency divider is shown in Fig. 2. The 1-mc signal is applied to the input 1 of the mixer and the 0.9-mc signal to the input 2. From these, the mixer forms a 0.1-mc sig-

nal which passes the 0.1-mc filter and can be derived at the output of an amplifier stage, but is also applied to a harmonic generator. The harmonic generator produces a spectrum from which the frequency of 0.9 mc is filtered out and fed back to the input 2 of the mixer. Once this operation is started it goes on as long as the frequency of 1 mc applied to the input 1 is of sufficient amplitude. Operation is started automatically by valve and thermal noise, the spectrum of which contains the frequencies of 0.1 and 0.9 mc.

The valve Rö3 of the Type XSA has the function of a mixer stage. Input 1 is the control grid; input 2 is coupled into the cathode. In the same manner as for the 1-mc output stage, the 0.1-mc output stage (Rö6-L6) is driven directly from a 0.1-mc filter (L4-C55) via a voltage divider consisting of C60, R44 and the control grid capacitance of Rö6. An additional output feeds the full filter voltage of approximately 52 v via C56 to the pentode harmonic generator Rö4, whose harmonics are produced through overdriving. The 0.9-mc component is filtered out with L5-C59 and fed to valve Rö3 via its cathode (input 2).

The output amplifier Rö6 is tuned to 0.1 mc by L6-C62. The two outputs (front and rear) are decoupled by the resistor R112. Using the switch S2, the output voltage can be checked with the aid of the germanium diode G16.

3.3 Power Supply

The power supply for the valves and the oven is accommodated on the mounting panel. The power transformer Tr1 has two identical primary windings for 110 v each. These can be connected, either in parallel or in series, by shorting links K1 (see Fig. 1), providing the voltages of 110 and 220 v. An additional winding permits addition or subtraction of 20 v through another link. Thus it is possible to select either

90 v, 110 v, 130 v, 200 v, 220 v or 240 v.

Separate rectifiers are provided for the contact-thermometer operated electronic control circuits of the oven and for the rest of the instrument, interaction thus being prevented. The rectifier G11 delivers the d-c voltage for the control circuits of the oven and for the heating of the inner oven, while G12 provides the anode supply and screen-grid

voltages for the valves Rö1 to Rö7 via the voltage stabilizing circuit Rö8-Rö9-Rö10. This circuit operates as follows: A power valve, Rö9, of low anode resistance functions as a variable series resistance placed ahead of the load. The load is connected to the cathode, the voltage source, G12, to the anode. Load in this sense are all the anodes and screen grids of the valves Rö1 to Rö7. The control grid of Rö9 connects via R77 to the anode of Rö8, having the same potential. Rö8 draws its anode supply voltage via R74-R75 from the voltage source G12. The cathode voltage is stabilized by the glow reference tube Rö10, and the grid bias is derived via the voltage divider R78-R79 from the load voltage to be controlled.

When, for example, the a-c supply voltage increases then the load voltage at the cathode also increases and the voltage at the grid of Rö8 along with it. While the cathode is kept on a constant level by Rö10 the negative grid bias decreases, causing a higher anode current to flow which in turn results in a voltage decrease at the anode of Rö8 and grid of Rö9. The variation of this voltage causes a variation of the anode resistance of Rö9, restoring the original voltage at the cathode. A 10-% supply voltage fluctuation causes the load voltage to change by about ±0.1%. The residual hum voltage after the filter C79-L8-C80 to 84 means a periodical voltage variation and is likewise balanced out by the circuit described.

The anode supply and screen grid voltages of the valves Rö1 and Rö2 are additionally stabilized by the smoothing valve Rö11 and isolated from the other power supply section. The filter C77-L7-C78 for G11 ensures that sine-wave and square-wave supply voltages of equal rms value produce the same d-c voltage. This is of importance when the instrument is fed from the Emergency Power Converter Type NNZ. The filter capacitor of the G12, consisting of C80 to C84, has a value of 80 µf. This is sufficient to maintain the operating voltages when a switchover is made from the a-c supply to the emergency power converter.

3.3.1 Control Valve for the Inner Oven

The heater current for the inner oven is also the anode supply voltage of the valves Rö12I and Rö13I placed in parallel. The heater current is

controlled by the thermometer Th2 which short-circuits the grid voltage across R67 to earth when +68°C are being exceeded. R67 permits the heater current for the inner oven to be adjusted. The grid voltage of the valves Rö12II and Rö13II are so adjusted with R66 that the effect which a fluctuating anode voltage has on the heating of the inner oven is balanced out across the common cathode resistor R61. Besides, this circuit provides also a positive feedback voltage which permits the thermometer Th2 to be operated by small control voltages thus ensuring a long life of the thermometer. Rö13II also operates the relay RsB enabling the functioning of the inner oven to be remote indicated via the contact bI. This can be used as a make or as break contact, functioning only as a switch which carries no voltage. For remote indication it is therefore necessary to connect a voltage source suitable for the indicating device. The power capacity of the relay contacts is 100 v maximum, 1 amp maximum, 30 w maximum. Via the contact bIII of the relay RsB, the pilot light R12 (see Fig. 3) is connected in circuit along with the heater circuit of the inner oven.

3.3.2 Control Valve for the Outer Oven

The outer oven is directly heated with alternating current, from the winding 8-9 of the transformer Tr1. On-off switching takes place via the contact aII of the relay RsA in the anode circuit of Rö14II. Contact aIII of this relay controls the pilot light R11 (see Fig. 3) and contact aI offers the possibility of remote checking of the outer oven, the considerations regarding the connection of the indicating device being the same as stated in section 3.3.1. The NTC resistors R87 and R88 present a very high resistance while cold and, together with C76, eliminate contact clicks. The operating current gradually lowers the resistance of R87 and R88 until nearly the full transformer voltage of 150 v_{rms} is available across the heater of the outer oven.

The thermometer Th1 in the outer oven (see Fig. 1) controls Rö14II by short-circuiting the grid voltage as soon as the temperature of the outer oven reaches 66°C. Rö14I produces a positive feedback voltage across the common cathode resistor R54 and thus enables a low level of control voltage to be used to prolong the life of the thermometer Th1.

.4 Regulated Heater Voltage

The parallel connected rectifiers G17 and G18 are fed from the winding 14-15. The current flows from the plus pole of the rectifier through the resistor R105 and the heaters of R61, R62 and R67 to the chassis and returns to the minus pole via the transistor T1.

The three transistors T1 to T3 in conjunction with the Zener diode G19 comprise a regulating arrangement which functions on the same principle as the voltage regulator arrangement described in paragraph 3.3. The transistor T1 functions as a variable resistor which is connected ahead of the load (heaters of R61, R62 and R67). T2 has no voltage gain and functions only as a cathode follower. The control voltage between the base and emitter of T2 is therefore very small. Thus the collector of T3 is at almost the same potential as the base of T1. The relatively large base current of T1 is provided by T2 so that the collector of T3 is not loaded. The transistor T3 is controlled for the most part from the difference between the voltage to be regulated and the constant voltage drop in the Zener diode G19. If, for example, the negative voltage across the load rises, T3 is driven so that it conducts more current whereby the base voltage of the transistor T2 as well as the base voltage of T1 changes in the positive direction. The transistor T1 functioning as a series resistor is driven so that its current is decreased and therefore works against the rising voltage.

The transistor T3 is not driven from the load voltage alone, but also by a small portion of the voltage directly from the rectifiers via the divider network R109-R110. As a result, the resistance of transistor T1, controlled via T2 and T3, becomes higher when the load voltage remains constant and only the voltage at the rectifiers rises. Thus the arrangement uses forward control whereby the influence of varying supply voltages upon the regulated heater voltage is almost eliminated.

Because of the special characteristics of the Zener diode, this circuit arrangement only permits a voltage of 7.5 v to be stabilized. Thus the adjustable resistor R103 is provided which reduces the voltage to the required 6.3 v.

The entire heater voltage regulator unit is designed as a separate chassis. It contains the transistors T1 to T3, the Zener diode G19, the resistors R107 to R110 and, supported in a spring, the rectifiers G17 and

G18. The regulator unit is fastened with four screws to the back side of the front panel; however, it is electrically isolated. At the same time, the power transistor T1 is mounted directly near the front panel so that the heat can be conducted away easily and thus the operating temperature of the transistor T1 cannot reach an excessive value.

4. Operating Instructions

4.1 Installation and Connections

It is good practice to locate the Frequency Standard Type XSA in a room of stable temperature as this will further reduce the slight effect of the ambient temperature on the frequency. Slight vibrations do not affect the performance of the instrument when the retaining screws of the oscillator chassis have been removed. Built to the German standard DIN 41490, the Frequency Standard Type XSA can readily be inserted in a standard rack 520 complying with DIN 41491 as does the rack of our Standard Time System Type CAA. 4 screws M6 x 12 DIN 933 are used to secure the set to the rack. Multi-pin plugs on the rear of the instrument mate with the corresponding sockets, B16, DIN 41621, provided at the rack. When the instrument is set up at its final location it is first necessary to remove the retaining screws from the spring-mounted oscillator chassis. To do this, loosen the screws marked A in Fig. 4. The oscillator chassis should be secured again during transportation in a vehicle.

If the instrument is not operated mounted in a rack, then the connections should be made by the customer himself, as stated below:

	Multi-pin connector St1 (see Fig. 1)
1a, 1b	90 v, 110 v, 130 v, 200 v, 220 v, 240 v, 47 to 63 cps, depending upon connection of shorting bars on voltage selector panel
2a, 2b	Neutral wire
3a, 3b, 4b	Rotary field of the synchro-system (x, y, z)
4a, 5a	Excitation of the synchro-system (u, v) 110 v, 47 to 63 cps
5b, 6a, 6b	Relay contact for remote checking of the inner oven (5b-6a closed means heater voltage ON)
7a, 7b, 8a	Relay contact for remote checking of the outer oven (7b-8a closed means heater voltage ON)

Multi-pin connector St2 (see Fig.1)

1b, 1a (chassis) 0.1-mc output; 1 v; output impedance 18 Ω

4.2 Preparation for Use

The instrument leaves our factory adjusted for a 220-v a-c supply voltage. To adjust it for operation from a supply voltage other than this, put the connecting link on the voltage selector panel to the proper terminal. The various connections possible are shown in Fig. 5. Use a 1-amp fuse for 90 v, 110 v, and 130 v, and a 600-ma fuse for 200 v, 220 v, and 240 v, inserting it into the fuse holder "Si" (see Fig. 1). Put the power switch up for ON. The pilot light R13 (Fig. 3) is the voltage indicator. Allow a warm-up period of 1 minute. The voltages that are the most important as well as the output voltages can then be checked with the switch S2 and the panel meter I1 (see Fig. 3). In every position of the CHECK switch the meter I1 should deflect within the black section of its range. Check after first-time switching on that the outer oven operates. At room temperature, this will occur after about one and a half hours and is manifested by the control lamp R11 turning off (see Fig. 3). Take the set out of service if the outer oven does not operate after two hours. Otherwise, overheating will occur.

The inner oven operates after another one and a half hours, the control lamp R12 turning off. Shortly after switching on, the output frequencies still differ considerably, i.e. by a few units of 10^{-6}, from the desired value. The vacuum-sealed crystal reaches its final temperature only after a warm-up period of 4 hours so that then the output frequencies are very close to the desired value. Accurate frequency adjustment should be made only after a running-in period of about 10 days, the time generally taken by crystal vibrators. This does not only hold for first-time operation but whenever the set has been temporarily switched off.

4.3 Frequency Adjustment by Use of a Standard

Frequency adjustment by comparison with a standard of known accuracy is best done with the aid of our Phase Comparator Type XKC together with the associated Recorder Type XKB. The way of doing this is detailed in the Instruction Book on the Type XKC. This assembly offers continuous recording and thus a better survey of the stability of the frequencies to be

compared. Unlike simpler methods this procedure allows also the direction of the frequency deviation to be read.

Where the above assembly is not available, the difference in the frequencies to be compared can either be displayed in the form of Lissajous figures or indicated on an r-f voltmeter connected between the two 0.1-mc or 1-mc outputs of the instruments to be compared. The period of a difference-frequency cycle can be measured with a stop watch. If the output impedance of the reference standard is about 60 Ω and the open-circuit voltage about 1 v, i.e. nearly similar as with the Type XSA, then the two outputs to be compared can be connected directly, the CHECK switch S2 put to 0.1 mc, or 1 mc, respectively, and the panel meter used for heat indication. To determine the direction of the frequency deviation, temporarily change the frequency adjustment by a known amount. For example, if the beat frequency increases with a positive frequency adjustment, i.e. with an adjustment in the direction of higher frequencies, then the frequency deviation is also positive.

If the actual value of the frequency has been found by one of the methods described, adjust for the desired value, using the knob FREQUENCY ADJUSTMENT. The mechanical register mounted over this knob displays the setting in terms of 10^{-10} of the nominal frequency, i.e. 10^{-5} in the case of 0.1 mc, 10^{-4} in the case of 1 mc. Note that the mechanical register adds for a negative frequency adjustment and subtracts for a positive one. This behaviour is appropriate as aging of crystals goes along with a positive frequency drift so that a negative frequency correction is necessary time and again. The sum total of all corrections made in the course of time to compensate for againg is therefore indicated as a positive number.

4.4 Frequency Correction against Standard Time Signals

Generally, the Frequency Standard Type XSA is operated in conjunction with our Standard Time System Type CAA. Daily comparison of its seconds signals with astronomically checked time tones permits the frequency of the Type XSA to be determined with high absolute accuracy, making it a primary frequency standard.

The way in which the time comparison is made is detailed in the Instruction Book on the Time Signal Oscillograph Type CAO. It is good practice

to measure the diurnal difference in error with reference to several astronomically checked time tones and to plot the result with the time as the abscissa. A positive difference in error indicates that the external time tone arrives later. A curve obtained from the average value over a long period of time enables the frequency error over the period of observation to be calculated with the aid of the following formula:

$$\frac{\Delta f}{f} = \frac{1}{86{,}400} \cdot \frac{\Delta s}{\Delta t} = 1.156 \cdot \frac{\Delta s}{\Delta t} \cdot 10^{-5} \qquad \left[\begin{matrix}\Delta s & \text{in sec.} \\ \Delta t & \text{in days}\end{matrix}\right]$$

where 86,400 is the number of seconds of the mean solar day, Δs the total change in error within the period of observation, and Δt the period of observation.

Generally, there will be a bend in the mean error curve if the period of observation is very long. This bend is due to the change in frequency causedby aging of the crystal. Aging can be determined by differentiation of the mean error curve at several points.

4.5 Determination of Aging

The mean error curve in Fig. 6 shows that the error is +25 msec on the day 0 of the period of observation. After 20 days, the error is -0.7 msec. The mean daily rate calculated therefrom for the tenth day is

$$\text{rate}_{10} = \frac{(-0.7 - 25) \times 10^{-3}}{20} = -1.285 \times 10^{-3} \qquad \left[\frac{\text{sec}}{\text{day}}\right]$$

This corresponds to a frequency error of

$$\frac{\Delta f_{10}}{f} = \frac{-1.285 \times 10^{-3}}{86{,}400} = -1.49 \times 10^{-8};$$

On the 72nd day, the tangent to the mean error curve is horizontal. Hence the rate is then: $\text{rate}_{72} = 0$. For the 130th day, the average between the 120th and the 140th days, one obtains

$$\text{rate}_{130} = \frac{17.5 - (-4)}{20} = 1.075 \times 10^{-3} \qquad \left[\frac{\text{sec}}{\text{day}}\right]$$

corresponding to a frequency error of

$$\frac{\Delta f_{130}}{f} = 1.245 \times 10^{-8}.$$

A good survey of the aging of the crystal is obtained if the frequency error or the rate, respectively, thus found for several points of the error curve is again shown in form of a curve. Fig. 7 illustrates the rate curve calculated from the mean error curve shown in Fig. 6. Where exacting demands are made on the frequency accuracy, familiar graphic methods may be employed to detect the law underlying the rate curve and thus to obtain extrapolated values of the rate. For a period of a few months, the rate curve can nearly always be replaced by a straight line. Effects of crystal againg can almost fully be balanced out by regular frequency correction with the aid of the extrapolated rate curve. For 120 days, the extrapolated rate curve shows a difference in rate of $3.55 \times 10^{-8} - 1.7 \times 10^{-8} = 1.83 \times 10^{-8}$. In the example quoted above, a daily negative frequency correction of

$$\frac{1.83 \times 10^{-8}}{120} = 1.52 \times 10^{-10}$$

would hence be necessary between Jan. 1 and May 1, but a correction by 15.2×10^{-10} made every 10 days would also be sufficient. The rate of aging decreases slightly so that a smaller daily frequency correction is necessary for further months. The further procedure is to replace the extrapolated rate curve by a measured one. When doing this, the daily negative frequency corrections must be added, with positive sign, to the rate values obtained from the new error curve which is much flatter. It is recommended that all adjustments be kept on record as this minimizes errors and incorrect manipulation.

5 Maintenance

5.1 Performance Check of Valves

The set uses long-life valves which will become defective only after several years in service. Where reliability is an absolute must, it is nec-

essary to check the performance data which are most important, using the panel meter and the CHECK switch. Keep a separate record of the readings taken in each position of the switch. This makes it possible to notice whether there is a gradual decrease in valve emission or whether a defect shows up. In this way a trouble is generally recognized long before it is serious enough to cause a breakdown. Attention is drawn above all to the filament voltage of the valves Rö1, Rö2, and Rö7, checked in the position FILAMENT, to the anode currents of the valves Rö1 and Rö2, checked in the position "Rö1, Rö2", and to the heater voltage of the inner oven, checked in position INNER. The last-named quantities are stabilized and should therefore always be at the same level. The values obtained in the final inspection at the factory can be seen from the inspection sheet supplied with every Frequency Standard Type XSA. All the other data are subject to slight variations due to the normal change in supply voltage.

5.2 Performance Check of the Oven

The operation of the oven is best checked by regular measurement of the on-off times of the inner oven. The relative ON period of the inner oven is normally between 40 and 60%. The total on-off period of the inner oven lasts for about 1 to 2 minutes. The ratings can be seen from the inspection sheet.

The on and off times of the outer oven depend greatly on the ambient temperature. Checking them regularly is useful only if the ambient temperature is also recorded or when it is very constant. Abnormal behaviour of the oven is indicative of a damaged or changed thermometer, say, due to heavy shocks during transportation. The thermometer cartridges may t e m p o r a r i l y be withdrawn from the oven during operation and be checked. To do this, turn the knurled knob marked K in Fig. 1 until the cover is moved away from the access hole and withdraw the thermometer. Use duck-bill pliers or a wire hook, twisting the thermometer gently. The capillary tube of the thermometer is visible in a longitudinal slot of the thermometer cartridge. A disintegrated mercury column can be caused to flow together by careful heating of the thermometer. It is imperative that the operating period of the set with the thermometers removed be as short as possible. Otherwise, there will be a change in temperature and, going

along with it, a change in frequency. Operation of the o u t e r o v e n with the thermometer removed will cause overheating when this condition continues for more than 30 minutes, and is therefore inadmissible. In contrast, the set is not imperilled when the inner oven is operated without thermometer, but the error in temperature of about 2°C results in a frequency change so that also the operating period with the inner thermometer removed should be kept to a minimum. When replacing the thermometers it is necessary to move them clockwise and counterclockwise until they are pushed against the stop. The opening in the outer cylinder must then be closed. Both ovens should go OFF within 3 minutes after replacement of the thermometers. If they do not, a trouble must be suspected and the set should be switched off if this cannot be eliminated within 10 minutes after operation without thermometer has already lasted for 30 minutes.

5.3 Replacement of Valves

If after several years of continuous operation a few valves have become defective then it is advisable to replace all the valves at the same time. Do not operate the set unless all the valves are inserted. In particular, Rö2 should by no means be removed during operation; otherwise, control of the amplitude of the crystal will be interrupted, thereby affecting its behaviour with respect to aging.

6. Table of Replaceable Parts

Ref. No.	Designation	Ratings	R&S Stock No.
C1	Capacitor, variable		E 444 111 - 10
C2	Trimmer, air	4 to 29 pf	CV 8125
C3	Capacitor, ceramic	Factory-adjusted	CCH 31/...
C4	Capacitor, ceramic	Factory-adjusted	CCH 31/...
C5	Capacitor, ceramic	Factory-adjusted	CCH 31/...
C6	Capacitor, ceramic	Factory-adjusted	CCH 31/...
C7	Capacitor, ceramic	Factory-adjusted	CCH 31/...
C8	Capacitor, ceramic	Factory-adjusted	CCH 31/...
C9	Capacitor, ceramic	Factory-adjusted	CCH 31/...
C10	Capacitor, ceramic	3 pf	CCG 41/3
C11	Capacitor, paper	50,000 pf/250 v	CIM 50 000/250
C13	Capacitor, paper	50,000 pf/250 v	CIM 50 000/250
C14	Capacitor, ceramic	33 pf	CCH 31/33
C15	Capacitor, paper	10,000 pf/500 v	CPD 10 000/500
C16	Capacitor, paper	10,000 pf/500 v	CPD 10 000/500
C17	Capacitor, paper	10,000 pf/500 v	CPD 10 000/500
C18	Capacitor, paper	10,000 pf/500 v	CPD 10 000/500
C19	Capacitor, paper	10,000 pf/500 v	CPD 10 000/500
C20	Capacitor, paper	10,000 pf/500 v	CPD 10 000/500
C21	Capacitor, paper	10,000 pf/500 v	CPD 10 000/500
C22	Capacitor, paper	10,000 pf/500 v	CPD 10 000/500
C23	Capacitor, paper	50,000 pf/250 v	CPD 50 000/250
C24	Capacitor, paper	10,000 pf/500 v	CPD 10 000/500
C25	Capacitor, paper	10,000 pf/500 v	CPD 10 000/500
C26	Capacitor, paper	10,000 pf/500 v	CPD 10 000/500

Ref. No.	Designation	Ratings	R&S Stock No.
C27	Capacitor, paper	10,000 pf/500 v	CPD 10 000/500
C28	Capacitor, paper	10,000 pf/500 v	CPD 10 000/500
C29	Capacitor, paper	10,000 pf/500 v	CPD 10 000/500
C30	Capacitor, paper	10,000 pf/500 v	CPD 10 000/500
C31	Capacitor, paper	10,000 pf/500 v	CPD 10 000/500
C32	Capacitor, paper	10,000 pf/500 v	CPD 10 000/500
C33	Capacitor, paper	10,000 pf/500 v	CPK 10 000/500
C34	Capacitor, paper	10,000 pf/250 v	CPK 10 000/250
C35	Capacitor, paper	50,000 pf/250 v	CPM 50 000/250
C36	Capacitor, paper	50,000 pf/250 v	CPM 50 000/250
C37	Capacitor, paper	50,000 pf/250 v	CPM 50 000/250
C38	Capacitor, paper	50,000 pf/250 v	CPM 50 000/250
C39	Capacitor, paper	50,000 pf/250 v	CPM 50 000/250
C41	Capacitor, ceramic	2×100 pf	CCH 31/100
C45	Capacitor, ceramic	22 pf	CCH 31/22
C46	Capacitor, synth. foil	200 pf/500 v	CKD 2/200/500
C49	Capacitor, synth. foil	10 000 pf/250 v	CKS 10 000/250
C50	Capacitor, ceramic	5 pf	CCG 41/5
C51	Capacitor, synth. foil	100 pf/125 v	CKD 1/100/125
C52	Capacitor, paper	25,000 pf/250 v	CPK 25 000/250
C53	Capacitor, paper	50,000 pf/250 v	CPM 50 000/250
C54	Capacitor, paper	50,000 pf/250 v	CPM 50 000/250
C55	Capacitor, synth. foil	800 pf/125 v	CKD 2/800/125
C56	Capacitor, synth. foil	50 pf/125 v	CKD 1/50/125
C57	Capacitor, paper	50,000 pf/250 v	CPM 50 000/250
C58	Capacitor, synth. foil	50 pf/500 v	CKD 2/50/500
C59	Capacitor, synth. foil	160 pf/500 v	CKD 2/160/500

Ref. No.	Designation	Ratings	R&S Stock No.
C60	Capacitor, ceramic	2 pf	CCG 41/2
C61	Capacitor, paper	50,000 pf/250 v	CPM 50 000/250
C62	Capacitor, synth. foil	1000 pf/500 v	CKS 1000/500
C63	Capacitor, paper	50,000 pf/250 v	CPK 50 000/250
C64	Capacitor, synth. foil	300 pf/500 v	CKS 300/500
C73	Capacitor, paper	25,000 pf/500 v	CPK 25 000/500
C74	Capacitor, paper	10,000 pf/250 v	CPK 10 000/250
C75	Capacitor, paper	25,000 pf/250 v	CPK 25 000/250
C76	Capacitor, paper	50,000 pf/500 v	CPK 50 000/500
C77	Capacitor, MP	1 µf/500 v	CMR 1/500
C78	Capacitor, MP	4 µf/500 v	CMR 4/500
C79	Capacitor, MP	16 µf/500 v	CMR 16/500
C80	Capacitor, MP	16 µf/500 v	CMR 16/500
C81	Capacitor, MP	16 µf/500 v	CMR 16/500
C82	Capacitor, MP	16 µf/500 v	CMR 16/500
C83	Capacitor, MP	16 µf/500 v	CMR 16/500
C84	Capacitor, MP	16 µf/500 v	CMR 16/500
C85	Capacitor, MP	4 µf/500 v	CMR 4/500
C86	Capacitor, MP	8 µf/160 v	CMR 8/160
C87	Capacitor, MP	8 µf/160 v	CMR 8/160
C88	Capacitor, MP	5000 µf/500 v	CPK 5000/500
C89	Capacitor, electrolytic	500 µf/35 v	CEE 21/500/35
C90	Capacitor, electrolytic	500 µf/35 v	CEE 21/500/35
C91	Capacitor, paper	10,000 pf/1000 v	CPK 10 000/1000
C92	Capacitor, paper	50,000 pf/250 v	CPK 50 000/250

Ref. No.	Designation	Ratings	R&S Stock No.
G11	Rectifier, selenium	250 v/35 ma	GNV 14/250/35
G12	Rectifier, selenium	250 v/35 ma	GNV 14/250/35
G14	Diode, silicon		GK/S 33
G15	Germanium diode		GK 2561
G16	Germanium diode		GK 2561
G17	Rectifier, selenium	25 v/450 ma	GNB 14/25/450 parallel
G18	Rectifier, selenium	25 v/450 ma	GNB 14/25/450 parallel
G19	Diode, Zener		GK Z 6
I1	Ammeter, moving-coil		INS 10104
K1	Cable, r-f		LKK 61 900
L1	Coil	1.3 mc	E 444 111 - 11.1
L2	Coil	1 mc	E 444 111 - 11.2
L3	Coil	1 mc	E 444 111 - 11.3
L4	Coil	100 kc	E 444 111 - 11.4
L5	Coil	900 kc	E 444 111 - 11.5
L6	Coil	100 kc	E 444 111 - 11.6
L7	Choke, power		DB 75/2
L8	Choke, power		DB 75/2
Mo1	Synchro-system		ZAM 28 005
Q1	Crystal (clock)	mc	

Ref. No.	Designation	Ratings	R&S Stock No.
R1	Heater winding	approx. 1750 Ω	E 444 111 - 11.8
R2	Heater winding	approx. 8700 Ω	E 444 111 - 11.9
R4	Resistor, depos. carbon	50 kΩ/0.25 w	WF 50 k/0,25
R5	Resistor, depos. carbon	50 kΩ/0.25 w	WF 50 k/0,25
R6	Resistor, depos. carbon	1.25 MΩ/0.25 w	WF 1,25 M/0,25
R7	Resistor, depos. carbon	500 Ω/0.1 w	WF 500/0,1
R8	Resistor, depos. carbon	40 kΩ/0.25 w	WF 40 k/0,25
R9	Resistor, depos. carbon	50 kΩ/0.25 w	WF 50 k/0,25
R10	Resistor, depos. carbon	500 Ω/0.1 w	WF 500/0,1
R11	Resistor, depos. carbon	1 kΩ/0.1 w	WF 1 k/0,1
R12	Resistor, depos. carbon	5 kΩ/0.1 w	WF 5 k/0,1
R13	Resistor, depos. carbon	2 MΩ/0.25 w	WF 2 M/0,25
R14	Resistor, depos. carbon	500 kΩ/0.25 w	WF 500 k/0,25
R15	Resistor, depos. carbon	600 Ω/0.1 w	WF 600/0,1
R16	Resistor, depos. carbon	20 kΩ/0.1 w	WF 20 k/0,1
R17	Resistor, depos. carbon	80 kΩ/0.1 w	WF 80 k/0,1
R18	Resistor, depos. carbon	50 kΩ/0.1 w	WF 50 k/0,1
R19	Resistor, depos. carbon	5 kΩ/0.1 w	WF 5 k/0,1
R20	Resistor, depos. carbon	1 MΩ/0.25 w	WF 1 M/0,25
R21	Resistor, depos. carbon	1 MΩ/0.25 w	WF 1 M/0,25
R22	Resistor, depos. carbon	200 kΩ/0.25 w	WF 200 k/0,25
R23	Resistor, depos. carbon	20 kΩ/0.25 w	WF 20 k/0,25
R24	Resistor, depos. carbon	40 Ω/0.1 w	WF 40/0,1
R25	Resistor, depos. carbon	2 MΩ/0.25 w	WF 2 M/0,25
R26	Resistor, depos. carbon	800 Ω/0.25 w	WF 800/0,25
R27	Resistor, depos. carbon	30 kΩ/0.1 w	WF 30 k/0,1
R28	Resistor, depos. carbon	20 kΩ/0.25 w	WF 20 k/0,25

Ref. No.	Designation	Ratings	R&S Stock No.
R29	Resistor, depos. carbon	5 kΩ/0.25 w	WF 5 k/0,25
R30	Resistor, depos. carbon	6 kΩ/0.25 w	WF 6 k/0,25
R31	Resistor, depos. carbon	500 kΩ/0.25 w	WF 500 k/0,25
R32	Resistor, depos. carbon	50 Ω/0.1 w	WF 50/0,1
R33	Resistor, depos. carbon	1.6 kΩ/0.1 w	WF 1,6 k/0,1
R34	Resistor, depos. carbon	25 kΩ/0.1 w	WF 25 k/0,1
R35	Resistor, depos. carbon	200 kΩ/0.1 w	WF 200 k/0,1
R36	Resistor, depos. carbon	10 kΩ/0.1 w	WF 10 k/0,1
R37	Resistor, depos. carbon	200 kΩ/0.25 w	WF 200 k/0,25
R38	Resistor, depos. carbon	500 kΩ/0.25 w	WF 500 k/0,25
R39	Resistor, depos. carbon	50 Ω/0.1 w	WF 50/0,1
R40	Resistor, depos. carbon	100 kΩ/0.25 w	WF 100 k/0,25
R41	Resistor, depos. carbon	40 kΩ/0.25 w	WF 40 k/0,25
R42	Resistor, depos. carbon	10 kΩ/0.1 w	WF 10 k/0,1
R43	Resistor, depos. carbon	500 Ω/0.1 w	WF 500/0,1
R44	Resistor, depos. carbon	500 kΩ/0.25 w	WF 500 k/0,25
R45	Resistor, depos. carbon	6 kΩ/0.25 w	WF 6 k/0,25
R46	Resistor, depos. carbon	500 Ω/0.1 w	WF 500/0,1
R47	Resistor, depos. carbon	300 kΩ/0.25 w	WF 300 k/0,25
R48	Resistor, depos. carbon	20 kΩ/0.25 w	WF 20 k/0,25
R49	Resistor, depos. carbon	12.5 kΩ/0.1 w	WF 12,5 k/0,1
R50	Resistor, depos. carbon	4 kΩ/0.1 w	WF 4 k/0,1
R51	Resistor, depos. carbon	25 kΩ/1 w	WF 25 k/1
R52	Resistor, depos. carbon	1 MΩ/0.5 w	WF 1 M/0,5
R53	Resistor, depos. carbon	40 kΩ/0.25 w	WF 40 k/0,25
R54	Resistor, depos. carbon	4 kΩ/0.5 w	WF 4 k/0,5
R55	Resistor, depos. carbon	500 kΩ/0.25 w	WF 500 k/0,25

Ref. No.	Designation	Ratings	R&S Stock No.
R56	Resistor, depos. carbon	50 kΩ/0.25 w	WF 50 k/0,25
R57	Resistor, depos. carbon	6 MΩ ±1 %/1 w	WF 6 M/1/1
R58	Resistor, depos. carbon	600 kΩ ±1 %/1 w	WF 600 k/1/1
R59	Resistor, depos. carbon	1 MΩ ±1 %/0.5 w	WF 1 M/1/0,5
R60	Resistor, depos. carbon	60 kΩ ±1 %/0.5 w	WF 60 k/1/0,5
R61	Resistor, depos. carbon	800 Ω ±1 %/0.5 w	WF 800/1/0,5
R62	Resistor, depos. carbon	10 Ω/0.25 w	WF 10/0,25
R63	Resistor, depos. carbon	500 kΩ/0.25 w	WF 500 k/0,25
R64	Resistor, depos. carbon	3 kΩ/1 w	WF 3 k/1
R65	Resistor, depos. carbon	600 kΩ ±1 %/0.5 w	WF 600 k/1/0,5
R66	Resistor, depos. carbon, variable	100 kΩ lin.	WS 7122 F/100 k
R67	Resistor, depos. carbon, variable	100 kΩ lin.	WS 7122 F/100 k
R68	Resistor, depos. carbon	80 kΩ/0.5 w	WF 80 k/0,5
R69	Resistor, depos. carbon	2 MΩ ±1 %/1 w	WF 2 M/1/1
R70	Resistor, depos. carbon	5 MΩ ±1 %/1 w	WF 5 M/1/1
R71	Resistor, depos. carbon	600 kΩ ±1 %/0.5 w	WF 600 k/1/0,5
R72	Resistor, depos. carbon	400 kΩ/0.5 w	WF 400 k/0,5
R73	Resistor, depos. carbon	1 MΩ/0.5 w	WF 1 M/0,5
R74	Resistor, depos. carbon	300 kΩ/0.5 w	WF 300 k/0,5
R75	Resistor, depos. carbon	1 MΩ/0.5 w	WF 1 M/0,5
R76	Resistor, depos. carbon	50 Ω/0.25 w	WF 50/0,25
R77	Resistor, depos. carbon	1 kΩ/0.25 w	WF 1 k/0,25
R78	Resistor, depos. carbon	80 kΩ ±1 %/0.5 w	WF 80 k/1/0,5
R79	Resistor, depos. carbon	100 kΩ ±1 %/0.5 w	WF 100 k/1/0,5
R80	Resistor, depos. carbon	8 kΩ ±1 %/1 w	WF 8 k/1/1
R81	Resistor, depos. carbon	6 kΩ ±1 %/1 w	WF 6 k/1/1

Ref. No.	Designation	Ratings	R&S Stock No.
R82	Resistor, depos. carbon	6 kΩ/2 w	WF 6 k/2
R83	Resistor, depos. carbon	80 kΩ/0.5 w	WF 80 k/0,5
R84	Resistor, depos. carbon	approx. 20 kΩ/0.25 w	WF 20 k/0,25
R85	Resistor, depos. carbon	800 kΩ/0.25 w	WF 800 k/0,25
R86	Resistor, depos. carbon	60 kΩ/0.25 w	WF 60 k/0,25
R87	Thermistor	2 kΩ	WHD 62/2 k
R88	Thermistor	2 kΩ	WHD 62/2 k
R89	Resistor, depos. carbon	50 Ω/0.25 w	WF 50/0,25
R90	Resistor, depos. carbon	50 Ω/0.25 w	WF 50/0,25
R91	Resistor, depos. carbon	1 MΩ/0.5 w	WF 1 M/0,5
R92	Resistor, depos. carbon	Factory-adjusted	WF ...
R93	Resistor, depos. carbon	40 kΩ/0.5 w	WF 40 k/0,5
R94	Resistor, depos. carbon	200 kΩ/0.5 w	WF 200 k/0,5
R95	Resistor, depos. carbon	250 kΩ/0.5 w	WF 250 k/0,5
R96	Resistor, depos. carbon	800 kΩ/0.5 w	WF 800 k/0,5
R97	Resistor, depos. carbon	10 Ω/0.25 w	WF 10/0,25
R98	Resistor, depos. carbon	50 Ω/0.25 w	WF 50/0,25
R99	Resistor, depos. carbon	1 kΩ/0.1 w	WF 1 k/0,1
R100	Resistor, depos. carbon	50 Ω/0.25 w	WF 50/0,25
R101	Resistor, depos. carbon	50 Ω/0.25 w	WF 50/0,25
R103	Resistor, wire-wound	2 Ω/4 w	WV 4/2
R107	Resistor, depos. carbon	1 kΩ/0.25 w	WF 1 k/0,25
R108	Resistor, depos. carbon	Factory-adjusted	WF ...
R109	Resistor, depos. carbon	1 kΩ/0.25 w	WF 1 k/0,25
R110	Resistor, depos. carbon	20 Ω/0.1 w	WF 20/0,1
R111	Resistor, depos. carbon	50 Ω/0.1 w	WF 50/0,1
R112	Resistor, depos. carbon	60 Ω/0.1 w	WF 60/0,1

Ref. No.	Designation	Ratings	R&S Stock No.
Rl1	Lamp, scale	12 v	RL 1121
Rl2	Lamp, scale	12 v	RL 1121
Rl3	Lamp, glow, miniature	220 v	RL 210
RsA	Relay		RSX 324 071
RsB	Relay		RSX 325 041
Rö1	Valve		EF 800
Rö2	Valve		EF 800
Rö3	Valve		EF 800
Rö4	Valve		EF 800
Rö5	Valve		EF 800
Rö6	Valve		EF 800
Rö7	Valve		EAA 901 S
Rö8	Valve		EF 800
Rö9	Valve		EL 803
Rö10	Reference tube		85 A 2
Rö11	Reference tube		85 A 2
Rö12	Valve		E 92 CC
Rö13	Valve		E 92 CC
Rö14	Valve		E 92 CC
S1	Switch		SRK 1
S2	Switch, wafer		SRN 311/32
Si1	Fuse		0,6 DIN 41 571

Ref. No.	Designation	Ratings	R&S Stock No.
T1	Transistor, power		GT/CTP 1109
T2	Transistor		GT/OC 604 spez.
T3	Transistor		GT/OC 604 spez.
Th1	Thermometer, contact		E 444 111-4.20.7 66° C
Th2	Thermometer, contact		E 444 111-4.20.7 68° C
Tr1	Transformer, power		E 444 111 - 11.7

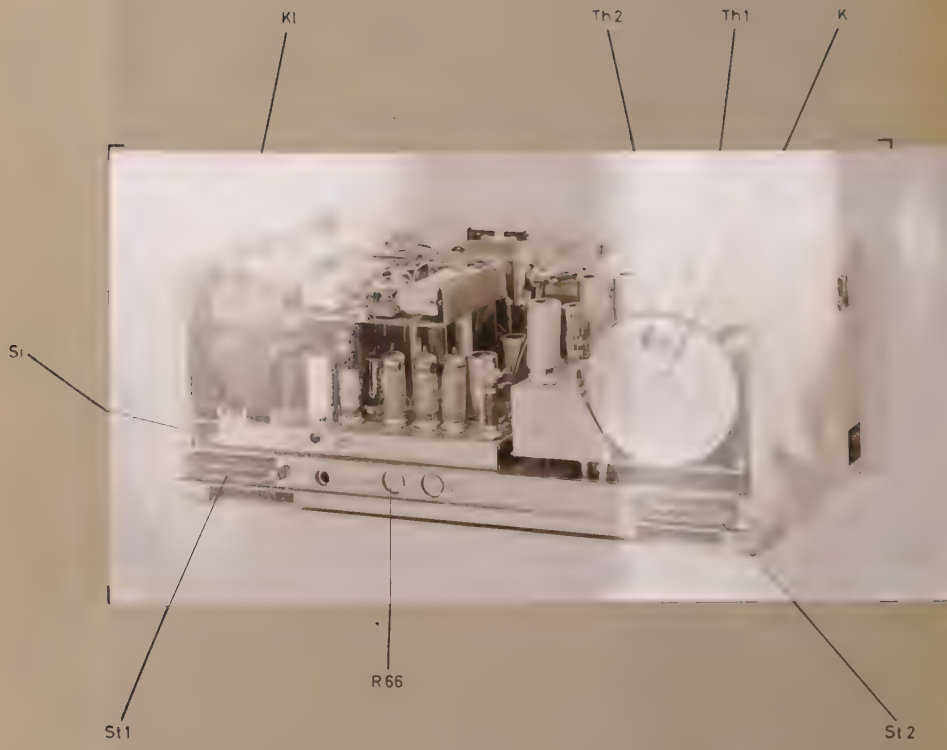


Fig. 1

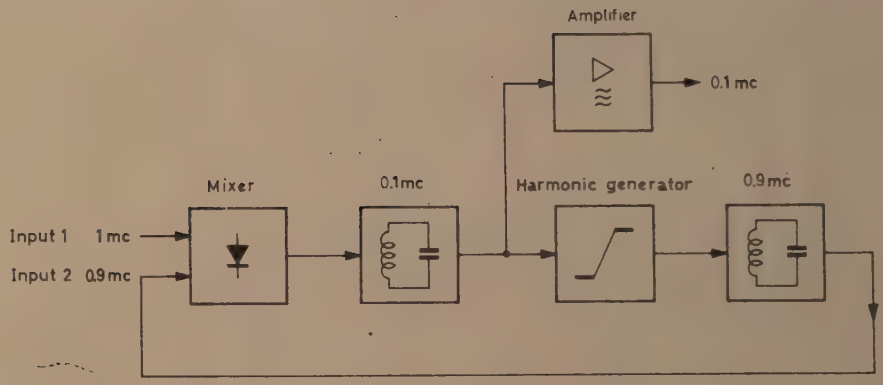

Amplifier
0.1 mc
Mixer
0.1mc
Harmonic generator
0.9mc
Input 1 1mc
Input 2 0.9mc

Fig. 2.

Fig. 3.

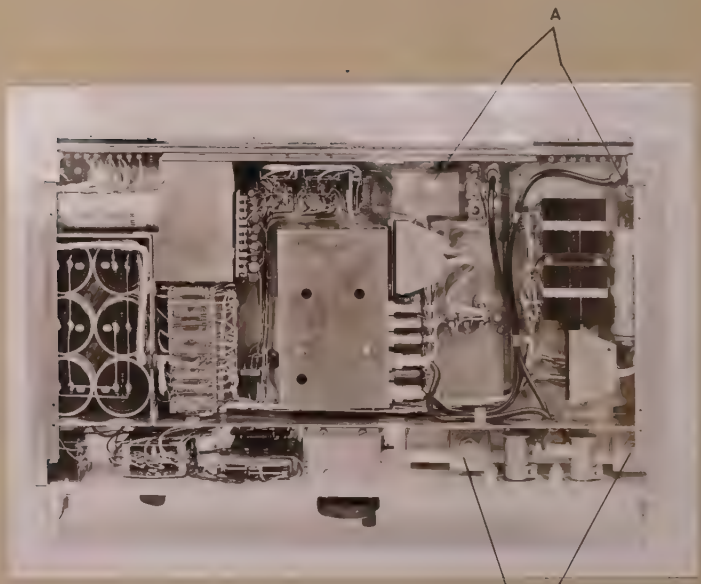


Fig. 4.

90 v

200 v

110 v

220 v

130 v

240 v

Fig. 5.

Rupp
948 1483

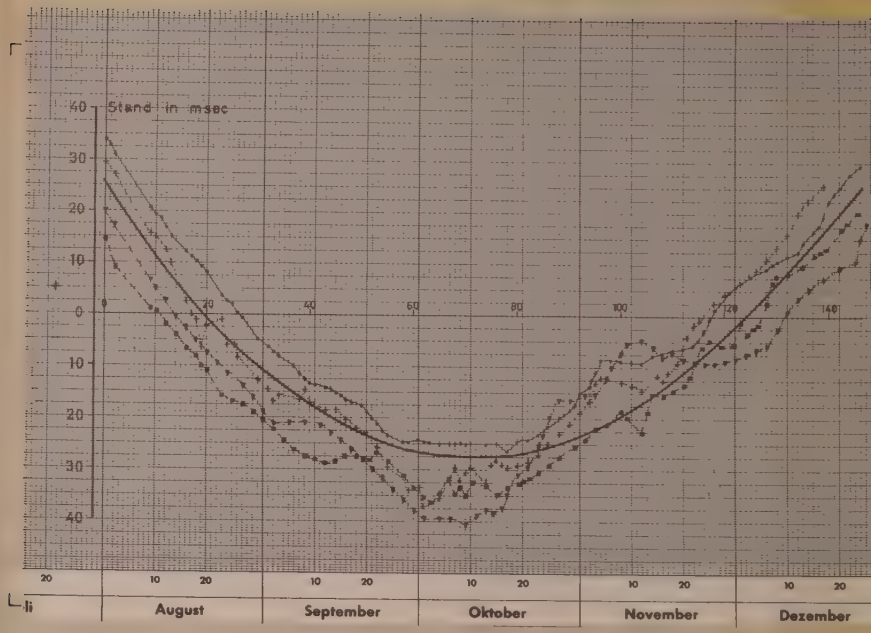

Stand in msec
40
30
20
10
0
10
20
30
40
20
40
60
80
100
120
140
10
20
August
September
Oktober
November
Dezember

Fig. 6.

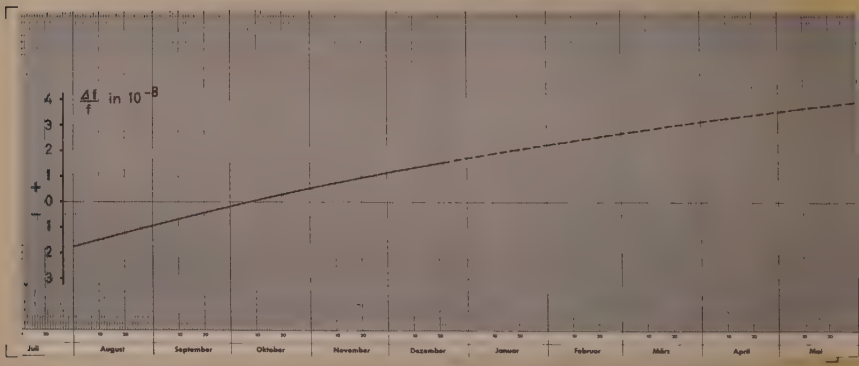
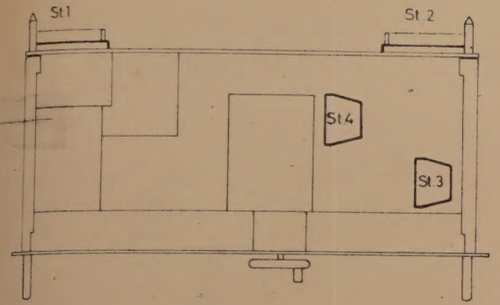
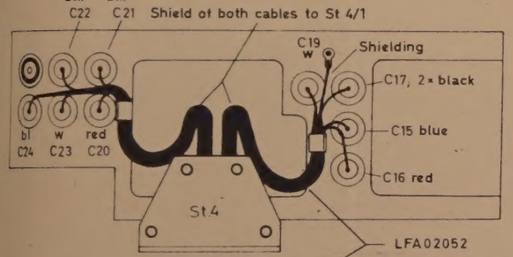

Δf/f in 10⁻⁸
4
3
2
1
0
1
2
3
Juli
August
September
Oktober
November
Dezember
Januar
Februar
März
April
Mai

Fig. 7.

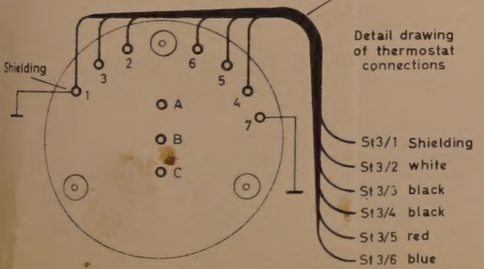
Set viewed from below



Detail drawing of plug 4



Detail drawing of thermostat connections

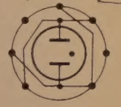


Rö 1, Rö 2, Rö 3, Rö 4
Rö 5, Rö 6, Rö 8
EF 800

Rö 7
EAA 901 S

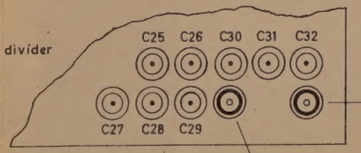
Rö 9
EL 803

Rö 10, Rö 11
85 A 2



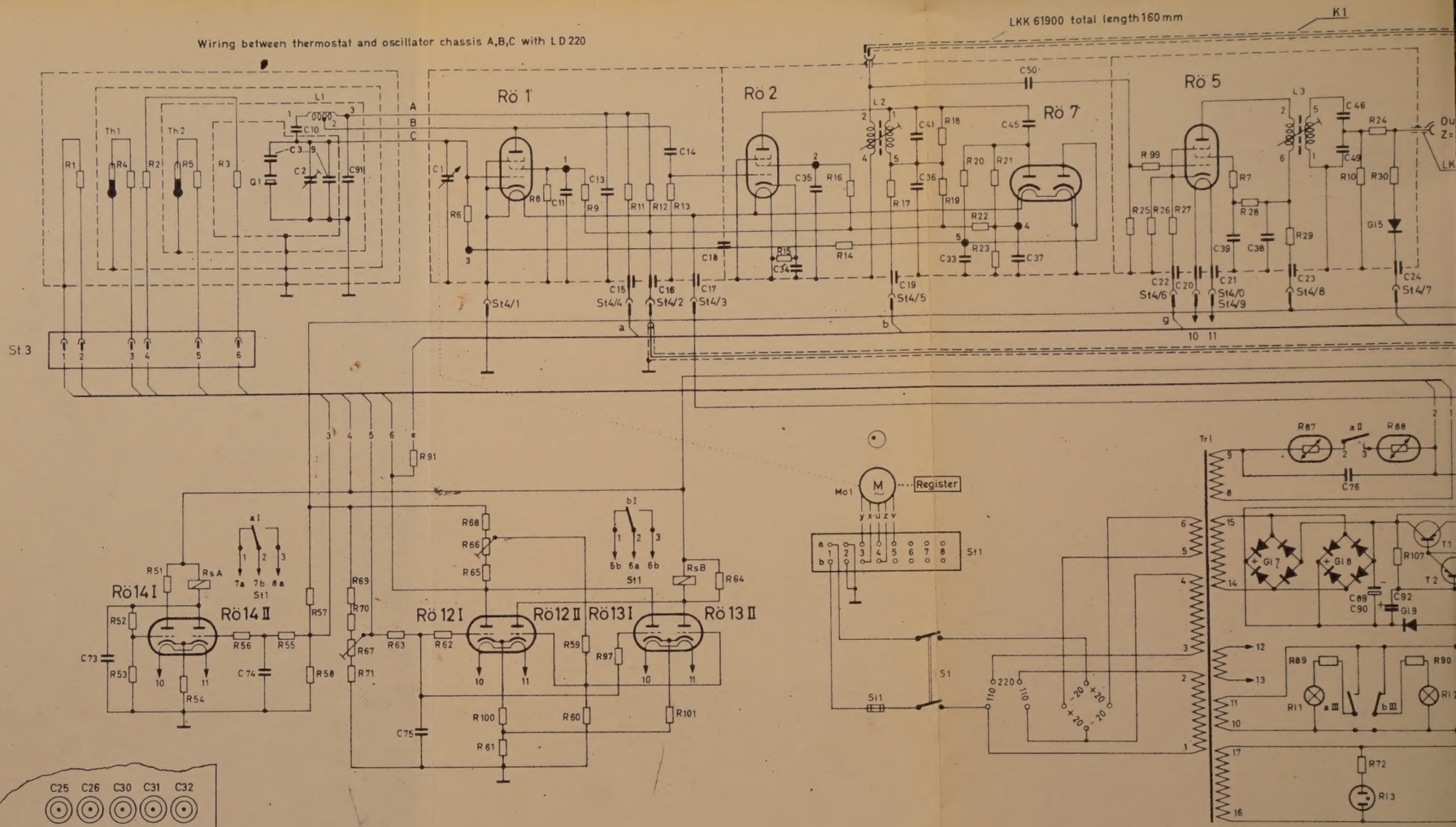
Rö 12, Rö 13, Rö 14
E 92 CC

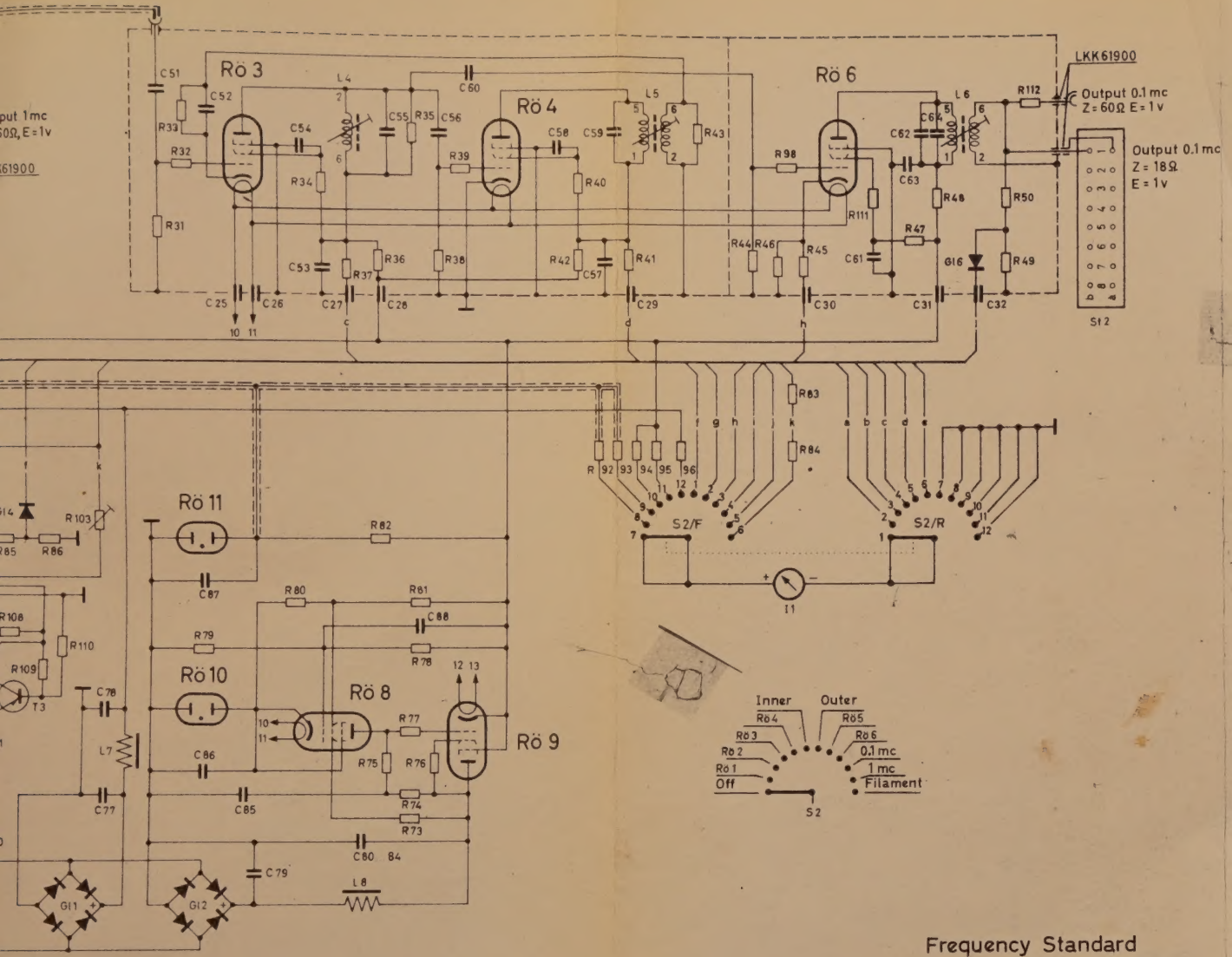
Connections: divider



Wiring between thermostat and oscillator chassis A,B,C with LD 220

LKK 61900 total length 160 mm





Frequency Standard
Type XSA BN 444111

82801